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ABSTRACT

The role of motor activity in children's formation of dynamic mental imagery was investigated in two experiments using a paired-associate recognition task. From the recognition data, it was inferred that (2) the child's ability to form dynamic images relating two objects undergoes its most rapid development between the ages of five and eight; and (b) the preimagery child can generate dynamic mental imagery in which two objects interact if he concurrently engages in overt manipulation of the objects. This is true even when the child has no visual access to his movements or to the objects being manipulated. These results offer strong support for Piaget's theoretical ideas concerning the role of overt and covert activity in the production of mental imagery. (Author/DB)

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THE ROLE OF OVERT ACTIVITY IN CHILDREN'S IMAGERY PRODUCTION

by Peter Wolff and Joel R. Levin

Report from the Project on Variables and
Processes in Cognitive Learning in Program 1,
Conditions and Processes of Learning

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Statement of Focus

The Wisconsin Research and Development Center for Cognitive Learning focuses on contributing to a better understanding of cognitive learning by children and youth and to the improvement of related educational practices. The strategy for research and development is comprehensive. It includes basic research to generate new knowledge about the conditions and processes of learning and about the processes of instruction, and the subsequent development of research-based instructional materials, many of which are designed for use by teachers and others for use by students. These materials are tested and refined in school settings. Throughout these operations behavioral scientists, curriculum experts, academic scholars, and school people interact, insuring that the results of Center activities are based soundly on knowledge of subject matter and cognitive learning and that they are applied to the improvement of educational practice.

This Technical Report is from the Project on Variables and Processes in Cognitive Learning in Program 1, Conditions and Processes of Learning. General objectives of the Program are to generate knowledge and develop general taxonomies, models, or theories of cognitive learning, and to utilize the knowledge in the development of curriculum materials and procedures. Contributing to these Program objectives, this project has these objectives: to ascertain the important variables in cognitive learning and to apply relevant knowledge to the development of instructional materials and to the programming of instruction for individual students; to clarify the basic processes and abilities involved in concept learning; and to develop a system of individually guided motivation for use in the elementary school.

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Abstract

The role of motor activity in children's formation of dynamic mental imagery was investigated in two experiments using a paired-associate recognition task. From the recognition data it was inferred that (a) the child's ability to form dynamic images relating two objects undergoes its most rapid development between the ages of five and eight; and (b) the preimagery child can generate dynamic mental imagery in which two objects interact if he concurrently engages in overt manipulation of the objects. This is true even when the child has no visual access to his movements or to the objects being manipulated. These results offer strong support for Piaget's theoretical ideas concerning the role of overt and covert activity in the production of mental imagery.

I
Introduction

Research on learning in the last five years has left little doubt that the study of visual imagery and its development with age are important to an understanding of human cognitive activity (Reese, 1970). This research has shown that the use of imagery has a marked facilitative effect on performance in tasks requiring the learning of associations between both verbal and pictorial items.

Several types of manipulation involving imagery have demonstrated this facilitative effect in paired-associate (PA) learning: the use of imageable versus relatively nonimageable noun pairs (Paivio, 1965; 1969); the use of picture versus word pairs (Dilley & Paivio, 1968; Rohwer, Lynch, Levin, & Suzuki, 1967); the imposition of an interacting image by a picture relating stimulus and response items (Davidson & Adams, 1970; Epstein, Rock, & Zuckerman, 1960; Reese, 1970; Rohwer, 1967); and instructions to the subject to form mental images relating the members of each pair (Bower, in press; Yuille & Paivio, 1968).

The present research is concerned with both the developmental course of imagery production and the processes involved in the production of imagery by children. Within both Piagetian and Soviet developmental psychology, the imaging process is inextricably linked to overt or covert motor activity. According to Piaget (Piaget, 1962; Piaget & Inhelder, 1967; Piaget, Inhelder, & Szeminska, 1964), the origin of both perception and imagery is in the motor imitative activity of the child. To represent an unseen object, the child must be able to recreate the motor components that constructed the original percept. Quoting Piaget, "...considered from the point of view of its origin, the image is a product of imitation. It is, in fact, an internalized imitation, one that can be made without resort to external gestures, though it is at first associated with such gestures...." (Piaget & Inhelder, 1967, p. 40).

With tactual input alone, the child can represent familiar objects by a static mental image at between three and four years of age (Page, 1959; Piaget & Inhelder, 1967). However, the formation of dynamic mental images, involving transformations of the objects themselves or systematic changes in their spatial position does not occur until approximately seven years of age, or the end of the preoperational period. This delay in the appearance of dynamic mental imagery occurs because, in Piaget's view, the production of a dynamic image involves the use of rudimentary mental operations similar to those which later govern classificatory behavior, conservation, and logical thought. These operations, while reversible, are not structured into the closed systems which characterize thought at the stages of concrete and formal operations. Since dynamic image production is known to markedly facilitate memory for paired associates, a useful technique is available to examine this process and its development in children.

Although it has been demonstrated (Milgram, 1967; Reese, 1965) that even preschool children are aided on a paired-associate task by a composite picture displaying an interaction (an imposed image), the evidence is not as clear for conditions under which Ss are required to generate their own dynamic images. Levin and Kaplan, in an unpublished study, have reported that sixth-grade Ss instructed to use self-generated imagery to associate pairs of familiar pictures far out-performed their nonimagery counterparts.

While the Levin and Kaplan data indicate that children in the upper elementary grades are capable of generating dynamic images from pictorial material to facilitate a paired-associate task, an experiment by Montague (1970) suggests that children of first-grade

age (albeit from lower socioeconomic levels) are not. For these Ss an imposed image of the type used by Davidson and Adams (1970) and Reese (1970) facilitated performance relative to a control group that was shown side-by-side pictures. However, the performance of Ss who were instructed to employ a self-generated imagery strategy did not differ significantly from that of either the control group or a group that labeled the pictures as they were displayed.

Thus, while five-year-old children apparently can utilize imposed imagery to remember picture pairs, there is an indication that the ability to generate dynamic imagery relating the elements of the pairs develops between the ages of seven and eleven. The purpose of the first experiment was to identify more precisely the age range over which the child's ability to form dynamic images undergoes its most accelerated development. It was reasoned that children who cannot generate these images should show no facilitation on a paired-associate task from imagery instructions, relative to a regular instructions group. At the other extreme, children with well-developed imaging processes should demonstrate the same degree of facilitation from imagery instruction as from an imposed image.

Two types of imposed images were included in the present experiment--those produced by the experimenter, and those generated by the subject himself. Experimenter-produced images were used to provide continuity with the research reported above which has demonstrated the facilitative effect of imposed images on PA learning. In the subject-produced imagery condition, Ss generated their own interacting imagery by manipulating the members of each pair, which in this research were real objects. This condition actually provides a more logical comparison with the imagery instruction condition, which also requires active, although covert, imagery production by S. Its inclusion in Experiment I allowed direct observation of S's ability to generate interactive visual imagery.

II
Experiment I

Method

Materials. The objects to be paired were 32 common children's toys, e.g., a metal airplane, a stuffed felt giraffe, a toy wristwatch, a plastic bear, a wooden block, a plastic truck, etc. All toys were representational and easily identifiable by Ss. They varied in size from 1 to 6 in. on the widest dimension. None of the toys had mechanical moving parts.

One paired-associate list was formed by randomly pairing the 32 toys, forming 16 pairs. A second list was then constructed by randomly recombining the 16 stimuli and 16 responses of the first list.

During the experiment, the stimulus and response toys were kept in separate boxes. The raised lids of these boxes prevented S from seeing the toys until they were presented in the learning task.

Procedure. The S was seated at a table opposite one E, who presented all stimuli during initial exposure and test. A second E, seated at one end of the table, handed the stimuli to the first E and recorded S's responses on the test trial. A one-trial study-test PA method was employed.

Subjects were assigned randomly to one of the four following conditions:

1. Control - Each pair of toys was placed in front of S, who was instructed to "remember which toys go together."

2. Imagery - The Ss were instructed to form a mental image of the toys in each pair "playing together."

3. E-Manipulate - Each pair of toys was made to interact in a pre-established manner by E.

4. S-Manipulate - The Ss were instructed to make each pair of toys play together by actually manipulating the toys.

After S was seated, the procedures to be followed during both study and test were explained. Each part of the instructions was illustrated with an example, using actual toys. After the instructions, S was given a second example. The toys used for the examples were not used in the actual task. For Ss in the S-Manipulate and Imagery conditions, possible interactions were illustrated using the practice toys. All Ss appeared to understand the requirements of the task.

Following the practice trials, each of the 16 experimental pairs was presented for approximately 7 seconds, with a 1-second interval between pairs. Stimulus duration was timed by E-1 counting to himself and was occasionally checked against a watch by E-2. Each pair was removed from sight before the next pair was shown. In none of the experimental conditions were the toys labeled by E.

In the E-Manipulate condition the toys were made to interact in a predetermined fashion, e.g., the toy wristwatch was wrapped around the giraffe's neck, the bear jumped into the truck and the two rode around the table, etc. The interaction between each pair of toys was different for each pair, but was the same for all Ss in this condition. In most cases the interactions matched quite closely those produced by Ss in the S-Manipulate condition.

After all the pairs had been presented, Ss were tested by the recognition method. This procedure was used to avoid the possible additional task requirement of translating from image to verbal report (Bower, in press). The 16 response toys were arrayed in front of the

child, while the stimulus toys were displayed one at a time. The S was required to hand E the response toy with which the stimulus toy had been paired previously. After S's choice was recorded, the selected toy was returned to its position in the array. No feedback was provided regarding the correctness of S's response. If S did not respond within 7 seconds, an incorrect response was scored and the next stimulus toy was presented. Order of presentation of test stimuli was randomly determined for each list, but was constant within each list.

A random order of list presentation was followed, with the four conditions randomly ordered within each list. Thus, each quartet of Ss represented a replication of the experiment within the same list.

Subjects. Eighty children, 40 each from the kindergarten and third grade of a middle-class elementary school in the Midwest, served as Ss. All were randomly assigned (in equal numbers) to the eight list/condition combinations.

Results

Learning was measured in terms of the number of correct selections out of 16 made by S following a single study trial. Chance performance was one correct selection. Figure 1 displays the mean number of correct responses for each age group under each condition. In the corresponding analysis of variance, conditions and lists were nested within age, in order that simple effects involving conditions could be examined within each age group. All hypotheses were tested with the probability of a Type I error (α) set equal to .05.

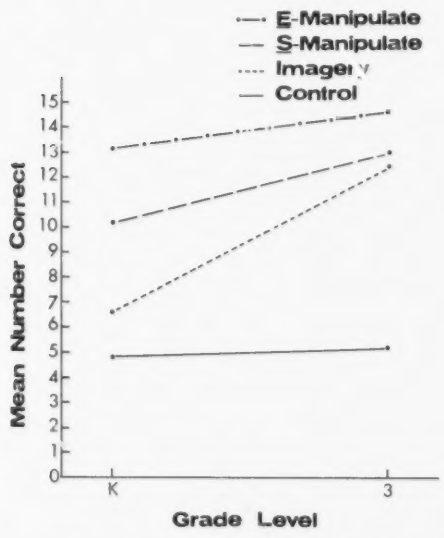

Fig. 1. Mean number of correct responses (out of 16) by kindergarten and third grade children in each of the four presentation conditions of Experiment I.

Third-grade Ss performed significantly better than kindergarten Ss: $F(1,64) = 17.97$, $p < .001$. The simple effect of Conditions was significant within the kindergarten sample: $F(3,64) = 20.17$, $p < .001$ and within the third-grade sample: $F(3,64) = 25.00$, $p < .001$. Pairwise comparisons of conditions within each age group were performed using Tukey's procedure with $\alpha = .05$. Within the kindergarten sample, performance in both the E-Manipulate and S-Manipulate conditions was significantly better than performance in either the Imagery or Control conditions. Neither E- and S-Manipulate, nor Imagery and Control, differed significantly from one another.

In the third-grade sample the Imagery, E-Manipulate, and S-Manipulate conditions were superior to the Control conditions, but did not differ significantly from each other.

The List effect was significant for kindergarten Ss: $F(1,64) = 5.19$, $p < .05$, as was the Conditions by List interaction: $F(3,64) = 3.92$, $p < .05$. This interaction is shown in Table 1. Scheffé post hoc comparisons ($\alpha = .05$) involving tetrad differences (Marascuilo & Levin, 1970) revealed that the List A over List B advantage was relatively greater for the Imagery and S-Manipulate conditions combined than for the E-Manipulate and Control conditions combined. No effects involving the List factor were significant for the third graders.

Discussion

The overt interaction of stimulus and response items, initiated either by E or by S, produced a marked facilitative effect on paired-associate learning. This was true at both the third grade and kindergarten levels. Rohwer, Lynch, Levin, and Suzuki (1968), using a filmed presentation of object pairs, found that an animated interaction resulted in even greater facilitation than a static interaction involving the same pairs. It is likely, therefore, that the manipulation conditions of the present study represented an optimal mode of nonverbal elaboration with material of this type.

Table 1. Mean Number of Correct Responses for the Kindergarten Sample as a Function of Conditions and List

List	Conditions			
	Control	Imagery	S-Manipulate	E-Manipulate
A	3.8	8.6	12.8	13.4
B	5.8	4.6	7.6	13.0

This may be contrasted with the corresponding effect of instructions to generate dynamic visual images. Kindergarten Ss receiving imagery instructions performed no better than nonimagery controls. This finding suggests that the child's ability to form dynamic mental images--or at least his ability to covertly generate and use them without additional support--is minimal at five and a half years. By approximately eight and a half years, the Imagery condition (covert imagery produced by S) facilitated learning to the same degree as the S-Manipulate condition (overt imagery produced by S): 12.3 and 12.9 correct responses, respectively, as compared with 5.1 in the Control condition. Thus, Piaget's assertion that the production of dynamic imagery by the child should occur at the end of the preoperational period, or at about seven years, is certainly compatible with these results.

Based on the proposed relationship between motor activity and imagery, one of the authors (PW) had predicted that S-produced activity would facilitate PA performance more than activity produced by E. In fact, the results are in the opposite direction, and for kindergarten Ss the superiority of E- over S-Manipulate was nearly detected by the Tukey post hoc procedure. While kindergarten Ss could not always generate an interaction for some of the pairs, in the E-Manipulate condition, a salient interaction was guaranteed for every pair. Further research is indicated in which the nature of the interaction available to each of these groups is more carefully controlled, perhaps by the use of yoked pairs of Ss, one designated as a performer and the other an observer.

Even though the S-Manipulate and Imagery overall performance means were quite different in the kindergarten sample, the significant, but admittedly fortuitous, List effects suggest that imagery and overt activity may have similar origins. The difference in performance on List A and List B pairs was similar for the S-Manipulate and Imagery conditions, and statistically different from that of the combined E-Manipulate and Control conditions. It is thus possible that those factors that are important for overt manipulation are also related to covert imagery production.

As mentioned earlier, Piaget claims that the production of mental imagery originates ontogenetically in the motor activity of the child. At first, imagery production depends on the overt production of a motor gesture, but at a later age, an internal perceptual-cognitive operation can replace the overt activity. In Experiment I, the S-Manipulate condition provided the child with an opportunity to produce a dynamic image motorically. Such an overt imagery condition was found to be facilitative for both older and younger children. In this condition, however, motoric production of the interacting imagery is confounded with S's observation of the consequences of his actions. As shown by the results of the E-Manipulate condition, this visual input in itself leads to marked facilitation. A strong implication of Piaget's claim is that children too young to form dynamic images without movement should be able to generate mental imagery if they are concurrently engaged in overt manipulation of the object pairs, even if they cannot see the results of their actions. This hypothesis was tested in Experiment II.

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III
Experiment II

Method

Design and Materials. To provide a way in which Ss could manipulate the toys without concurrent visual input, a "house" was constructed from a cardboard box, 20 in. long, 10 in. wide, and 12 in deep. The lower half of the front of the box was removed and replaced with a cloth curtain. The back of the box was also removed so that E could observe S's actions. The box was stationed in front of S, 6 in. from the edge of the table.

Because Ss in this study manipulated toys which they could not see, five of the very small toys and two toys which had sharp edges were removed from the lists used in Experiment I, shortening each list to 12 pairs.

The Ss in the Imagery condition were told to look at each pair of toys, and then to take them into the house, one in each hand, and imagine the toys playing together--to make up a picture in their heads of the toys playing. They were not allowed to move their hands once the toys were inside the house. The Ss in the Manipulate condition were told to take the toys into the house and make them play together, while trying to make up a picture in their heads of whatever the toys were doing. Unlike the first experiment, in Experiment II, Ss in both the Manipulate and Imagery conditions were allowed to hold the toys on the study trials, thus eliminating tactual cues as a plausible rival hypothesis for any Manipulate-Imagery differences. Two examples were given during the instruction period, with possible interactions illustrated for both groups.

Procedure. The testing situation was identical to that of Experiment I, except that the E sitting to S's right presented the object pairs to S, while the E facing S recorded S's responses. After all pairs were presented, the box was removed, and S was tested as in Experiment I.

Subjects. Forty children, 20 kindergartners and 20 first graders from essentially the same population as in Experiment I, served as Ss. The first graders were employed in part to provide an adequate sample size, and in part to determine whether a developmental imagery difference occurs between kindergarten and the first grade.

Results

The mean number of correct responses as a function of Conditions and Grades is shown in Figure 2. Performance of children who engaged in overt, but invisible, activity was superior to that of children who did not move the objects: $F(1,32) = 18.89$, $p < .001$. First-grade Ss made more correct responses than

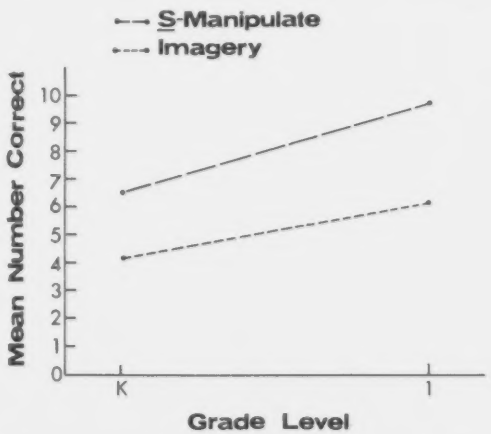

Fig. 2. Mean number of correct responses (out of 12) in Imagery and "invisible" Manipulate conditions for kindergarten and first grade children (Experiment II).

kindergarten Ss: $F(1,32) = 14.26$, $p < .001$. However, the Grades by Conditions interaction was not significant; neither were any of the effects involving Lists.

Discussion

Manipulation of the object pairs without visual input apparently allowed the formation of dynamic images by Ss who were otherwise unable to form them. The attitude of Ss in the Manipulate condition— head motionless, eyes turned "inward"— suggested that they were actually experiencing mental images of their activity, and Ss' subjective reports lend additional support to this conclusion.

In Experiment I, Ss in the S-Manipulate condition had visual access to the object pairs which they were manipulating, while in Experiment II they did not. Yet the amount of facilitation compared to the Imagery groups in the two studies was almost identical. In Experiment I, performance of the kindergarten sample in the S-Manipulate condition was 54.5% higher than that in the Imagery condition. In Experiment II, this figure was 58.5% for the kindergarten sample and 60.7% for the first grade. These results support Piaget's contention that the motoric activity plays a primary role in the production of dynamic imagery.

The importance of motor activity in perceptual processes and their development has been stressed by several investigators besides Piaget (Festinger, Ono, Burnham, & Bamber, 1967; Gyr, in press; Gyr, Brown, Willey, & Zivian, 1966; Hebb, 1949; Held & Hein, 1967; Wolff, 1969; Zinchenko, in Zaporozhets, 1965). Zinchenko reports that recognition ability for nonsense forms increases at the same time as the child's ocular or tactual scanning patterns become more closely correlated with the outlines of the forms. After approximately eight years of age, the amount of stimulus-correlated scanning necessary for correct recognition decreases, until finally the subject can process the stimulus "at a glance." Wolff (1969) found that children from four to seven years of age who voluntarily traced two-dimensional nonsense forms with their hands while looking at the forms recognized the forms better in an immediate recognition task than children who did not trace. Furthermore, the degree of facilitation from overt activity tended to decrease with age. The evidence from this research and the present experiments suggests that, until approximately the age of five, the generation of a percept or a dynamic image depends on concomitant motor output which duplicates the form of the perceptual response. With development, however, these perceptual processes come to depend less and less on overt production of motor activity. Piaget (Piaget & Inhelder, 1967), discussing the development of imagery production, has proposed that the overt gesture becomes "internalized," while Festinger et al. (1967) invoked the concept of "efferent readiness" to explain perception without overt activity. Further research and theory will hopefully define in greater detail the transitions that take place in these perceptual processes as they become independent of overt activity.

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